Initial Project Description Report

Contract No. W9132T-04-C-0016

Arizona State University East
Photovoltaic Testing Laboratory

A ONE YEAR DEMONSTRATION PROJECT UTILIZING TWO DIFFERENT FUEL CELL UNITS AT THE US ARMY'S SYLVESTRE HERRERA RESERVE CENTER, MESA ARIZONA

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Silvestre Herrera Reserve Center
Mesa, Arizona

August 30, 2004

Executive Summary

Two PEM fuel cells will be used in this demonstration project at the Sergeant Silvestre S. Herrera United States Army Reserve Center in Mesa, Arizona, Building 602. The manufacturers are Plug Power and Ida Tech. Both units are rated as approximately 5 kilowatt units, but both will be set to the 2.5 or 2.0 kilowatt setpoints for the duration of the test. Both fuel cells will be using natural gas as their fuel and will be grid-connected. There is no plan to attempt during this demonstration to use the thermal energy provided by these units. The building to which the fuel cells will provide AC electrical energy has most recently been used as the main training site at the Williams Gateway Airport location in Mesa. A new building has been constructed and will be moved into during the month of September, 2004. Building 602 will be used for other units that will be moving in, however, the electrical loads in the building will be less. Even so, the energy provided by the fuel cells will only be a fraction of that required. Of interest in this demonstration is the ability of two fuel cells, made by different manufacturers, to operate well in parallel during the required demonstration time. Contract award for this demonstration is $429,907. The local host site individual is Mr. James B. Cresto, Project Manager, 63rd RSC Engineer, whose e-mail address is James.Cresto.TADPGS@usarc-emh2.army.mil. His cell phone is 480-650-6164.

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

An one year demonstration project utilizing two different fuel cell units at the US Army's Silvestre Herrera Reserve Center, Mesa, Arizona.

2.0 Name, Address and Related Company Information

Photovoltaic Testing Laboratory, Arizona State University East
7349 E. Unity Avenue, Mesa, Arizona 85212
480-727-1220
DUNS number: 943360412
CAGE code: 4B293
Tax Payer ID number:

The Photovoltaic Testing Laboratory is a part of Arizona State University East, the campus of which is at the old Williams Air Force Base, Mesa, Arizona. It functions to provide qualification testing services to manufacturers in the photovoltaic industry, and also serves as a third party testing laboratory for Underwriters Laboratories. It engages in academic activities by providing alternate energy classes to graduate and undergraduate students at the university. Included in these courses is instruction in the theory and practical applications of fuel cells. Practical, hands-on training is provided. The demonstration program at the Sylvestre Herrera Reserve Center will give further opportunities for student involvement.

3.0 Production Capability of the Manufacturer

Product from two fuel cell manufacturers will be used in this demonstration program. Plug Power, 968 Albany Shaker Road, Latham, New York 12110. Scott Wilshire whose e-mail address is Scott_Wilshire@plugpower.com, telephone 518-782-7700 X 1338. In the past four years (as of May 2003) Plug Power has installed over 300 fully integrated fuel cells in field demonstrations. A GenSys 5CS unit is in process of being ordered for this demonstration.

Ida Tech, 63160 Britta Street, Bend, Oregon 97701 is the second fuel cell supplier. Contact information is Tucker Ruberti, whose e-mail address is <truberti@idatech.com> and whose telephone is 541-322-1046. Ida Tech manufactures approximately 25 fuel cell systems per year. It will supply a 5.0 kW PEM fuel cell system.

4.0 Principal Investigator(s)

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Director, Photovoltaic Testing Laboratory
Arizona State University East
7349 E. Unity Avenue
Mesa, Arizona 85212
480-727-1220 Voice
775-314-6458 FAX
e-mail: manit@asu.edu

5.0 Authorized Negotiator(s)

Ben Fasano	Dudley Sharp
Sponsored Projects Officer	Contracts Officer
Arizona State University	Arizona State University
480-727-1003	480-965-0273

6.0 Past Relevant Performance Information

(1) Project Title:
Establishment of Test Station for Fuel Cell Systems

Project Experience:
A test station has been established to evaluate residential fuel cell systems at Arizona State University. This project involved three major tasks: Site development, Fuel cell system metering, and Fuel cell system installation. These major tasks included several subtasks including: construction of concrete pad; installation of awning, natural gas line, water line, wall mounted electrical service entrance along with protection units, LAN, internet based DAS, weather station, water and natural gas flow meters and electrical power meters; Mounting fuel cell system on the concrete pad, interconnection with local electrical grid and meeting the requirements of the local inspectors for gas and electrical connections.

Sponsor Name and Related information:
Salt River Project
P.O. Box 52025
Phoenix, Arizona 85072-2025
Point of contact: Ernie Palomino; E-mail: gepalomi@srpnet.com
Phone: 602-236-3014; Fax: 602-236-3407

Service Agreement Number: 03-743; Contract award date: 12/15/02 – 4/1/03
Amount of the contract: $38,500

(2) Project Title:
Operation, On-Site Testing and Evaluation of a 5 kW Residential Fuel Cell System

Project Experience:
The fuel cell test station developed in the above project is now ready to be used to test a residential PEM, Proton Exchange Membrane, fuel cell system developed by a domestic manufacturer. This fuel cell system is commissioned and it is fully operational in both stand-alone and grid-connected modes. The primary objective of this project is to verify the manufacturer's performance claims and ratings. There are three major tasks involved in this project: Testing, Data Collection and Data Analysis. A slightly modified protocol of EPRI "Residential Fuel Cell Testing Protocol for Grid-Connected Operation" is scheduled to be followed to test this fuel cell system. The tests include: Start-up operations, normal shut-down operation, steady state operation, transient load operation, part-load operation, sudden loss of load testing, short-circuit testing, overload testing and endurance testing.

Sponsor Name and Related information:
Electrical Power Research Institute (EPRI) and Salt River Project

Point of contact:
David Thimsen, EPRI

E-mail: dthimsen@epri.com; Phone: (651) 766-8826; Fax: (651) 765-6375
Ernie Palomino, Salt River Project
E-mail: gepalomi@srpnet.com; Phone: 602-236-3014; Fax: 602-236-3407

Service Agreement Number: 03-0591; Contract award date: 01/01/03 – 07/31/04
Amount of the contract: $72,960

(3) Project Title:
Fuel Cell Based Uninterruptible Power Supply (UPS) for Computers

Project Experience:
Arizona Public Service (APS), a local electric utility company, donated three fuel cell stacks, ranging from 250 W to 2000 W, for the research and development activities of Arizona State University. One of the H-Power PEM250 fuel cell stacks was chosen to power a single personal computer. After extensive investigation, appropriate dc-dc converter and dc-ac inverter were identified and integrated with the fuel cell stack and the computer. This UPS system is fully operational and it has been determined a full 2500 psi tank of hydrogen could support a single PC for about 40 hours.

Sponsor Name and Related information:
Arizona Public Service
Pinnacle West Corp.
P.O. Box 53490
Phoenix, Arizona 85072-3940

Point of contact: Timothy McDonald; E-mail: Timothy.MCdonald@pinnaclewest.com
Phone: 602-250-3032

Contract: No funds were provided but APS donated several fuel cell stacks to ASU to support the research and development efforts of ASU

7.0 Host Facility Information

The host site will be the Sergeant Silvestre Herrera US Army Reserve Center, 6158 South Avery Street, Mesa, Arizona 85212. Point of contact at the 63rd Regional Readiness Command, Los Alamitos, California is Dr. Michael Siu, Chief, Facility Engineering. His telephone number is 562-795-2060; e-mail is: Michael.Siu@usarc-emh2.army.mil. Local contact is Mr. James B. Cresto, Project Manager, 63rd RCC Engineer, whose e-mail address is James.Cresto.TADPGS@usarc-emh2.army.mil. His cell phone is 480-650-6164.

Figure 1. Building 602, Sergeant Silvestre S. Herrera United States Army Reserve Center

The Sergeant Silvestre S. Herrera United States Army Reserve Center is located near the Williams Gateway Airport, Mesa, Arizona (formerly Williams Air Force Base). A new training center is being built by the 63rd RRC and is expected to be occupied in mid-September of 2004 (identification sign of new facility is shown above). The "old" center, Building 602, shown above in Figure 1, will still be used by the Army Reserve, housing newly assigned military units. Building 602 is where the two demonstration fuel cells will be located.

8.0 Fuel Cell Site Information

Location of the two fuel cells will be on the south side, and close to the mechanical equipment room, of Building 602, as shown in Figures 3 and 4. The main electrical breaker panel is within the mechanical room and will be fed by the electrical output of the fuel cells. Both units will be feeding the grid, and no attempt has been made to feed emergency power in the event of grid failure. Fuel cells are capable of stand-alone operation, but this feature was not considered for demonstration at this location.

A source of natural gas is readily available, as are city water, drains as well as access to communications lines.

A 14 foot by 20 foot area will be enclosed by security fencing plus an awning to shade the units from the direct rays of the Arizona sun. Within this enclosure the two fuel cell units will be mounted on portable steel platforms. NEMA 4 boxes are mounted on one end of the platforms to house the necessary electrical disconnect switches, as well as the metering and monitoring transducers for the required data collection. Each will be equipped with water conditioning apparatus to treat the very hard Arizona water. This method of mounting was chosen because it eases the dismantling and removal of the units from the

site on completion of the demonstration project. The units will then be relocated to the Arizona State University East campus and used in academic programs that will teach the basics of fuel cell operation.

Being able to assemble and test the units at the Photovoltaic Testing Laboratory location eases the logistics in getting the systems up and running. It then becomes a simple matter of fork lifting the units to their demonstration location some 200 yards away at Building 602. A picture, Figure 5, shows the PlugPower unit assembled to its platform, at the Photovlotaic Testing Laboratory.

Location of the Fuel Cell Platform at the Army Reserve Building

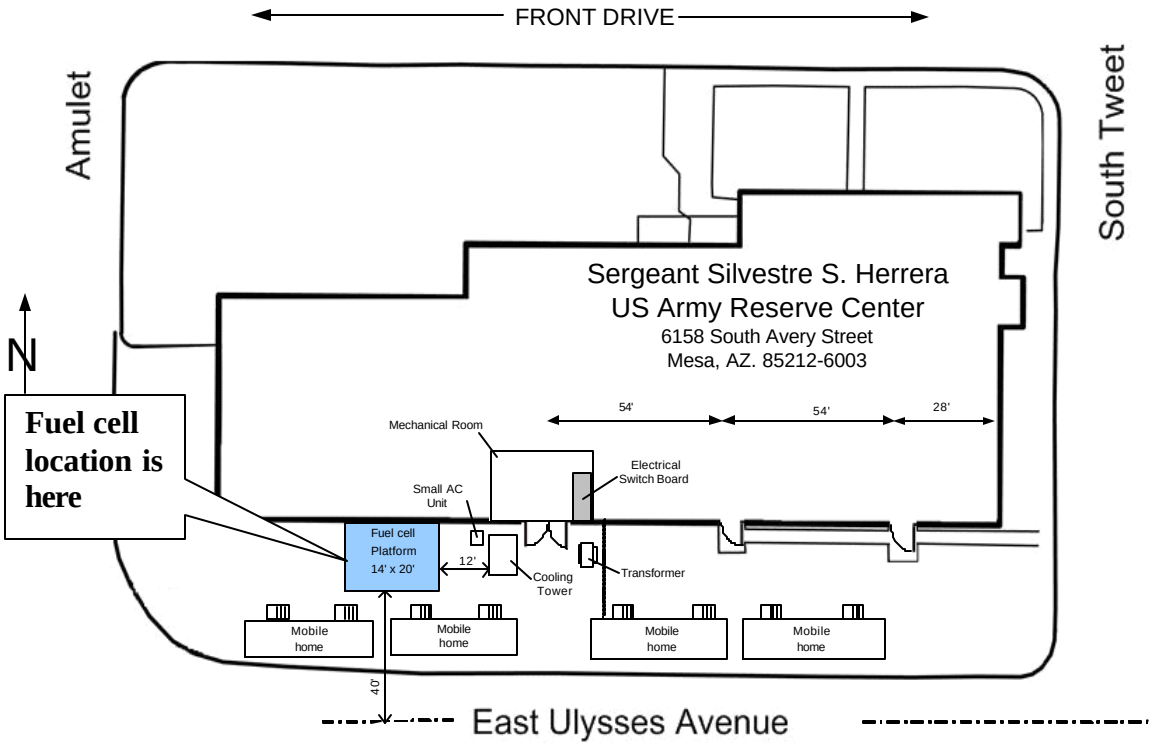


Figure 2. Layout of Building 602

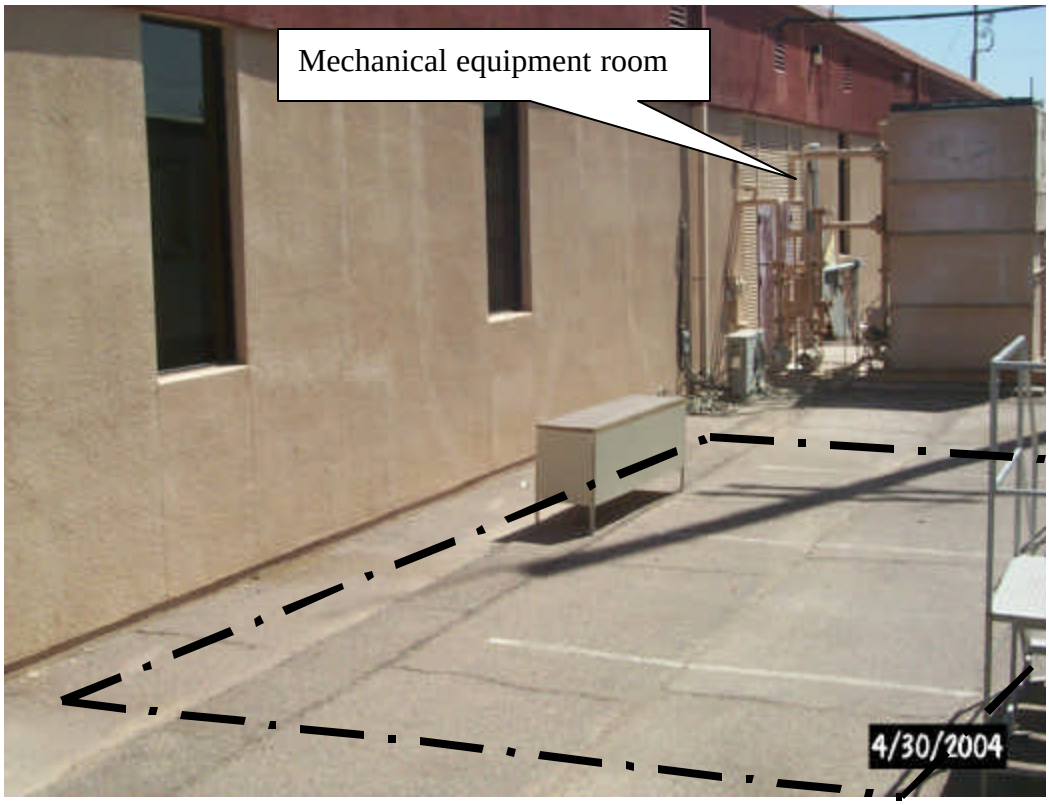


Figure 3. Approximate footprint of proposed location of the fuel cells within the lined area, south wall of Building 602

Figure 4. Mechanical equipment room at the site, south wall of Building 602

Figure 5. Plug Power fuel cell mounted on platform at the Photovoltaic Testing Laboratory

The PlugPower fuel cell is shown in Figure 5 in the process of being mounted on a portable platform at the Photovoltaic Testing Laboratory. The unit will be tested at this location, then moved using a forklift to the actual demonstration location (some 200 yards to the west). The second fuel cell, from IdaTech, will also be mounted on a similar platform and tested at the Laboratory before deployment to the test area at the Army Reserve Center. Why install fuel cells on movable mounting platforms? Because the fuel cell units will be returned to the Arizona State University East location, after the demonstration period, to be used as teaching tools in the University's alternate energy academic program.

9.0 Electrical System

Both fuel cells will provide between 2 and 2.5 kilowatts of power over the operating period of the demonstration period, at 120 volts AC output. The units are grid dependent and will be connected directly to the grid owned, as depicted schematically in Figure 6, and operated by the Salt River Project, through the building's electrical service entrance. No specific loads have been designated to be exclusively supplied by the fuel cells. Negotiations are continuing with Salt River Project for the interconnection

agreement of the two fuel cells. As is shown on the Status/Timeline, agreement signing should be complete by mid-September.

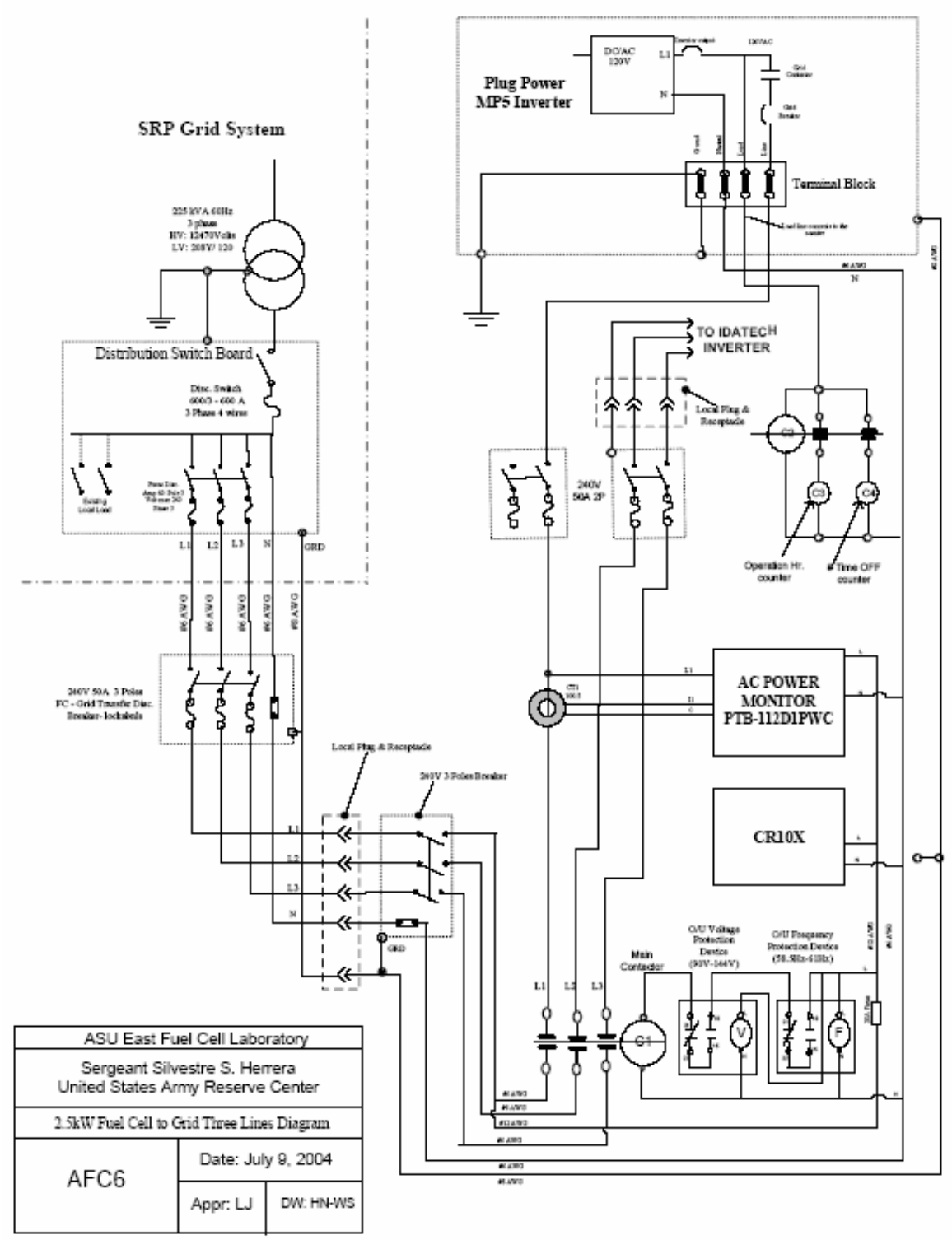


Figure 6. Fuel Cell connection to Electric Grid (3-Line diagram)

10.0 Thermal Recovery System

There are no plans at this present time to recover any thermal heat from these units.

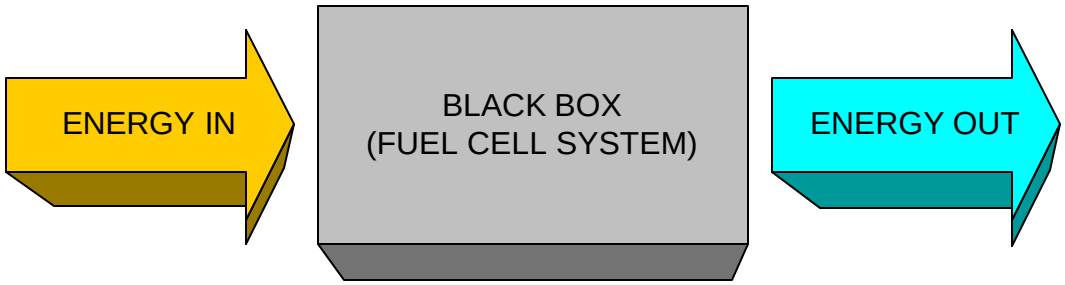
11.0 Data Acquisition System

The following parameters will be measured and submitted in a monthly report:

- Ambient temperature
- Battery temperature
- Water consumption
- Natural gas consumption
- Electrical energy supplied to grid
- Other temperatures deemed appropriate by ASU-PTL

Black Box Approach

Each of the above parameters will be measured externally to each fuel cell system. In this way, ASU-PTL will take a "black box" approach in observing each of the systems. Each system will use natural gas as an input fuel, and produce AC grid electricity to the local electric grid. Based on the "black box" approach, it does not matter to ASU-PTL what happens in between – within the processes of the system. The only concerns for the consumer are how much energy is consumed by the system, versus how much energy is produced. All external data will be reduced into 10-minute intervals.



In addition to the external system measurements, each manufacturer should supply its own internal system data. These data will be reduced and compared with external measurements over the period of the one-year of operation.

Configuration

ASU-PTL will collect external data in ten-minute intervals, and store it into Campbell Scientific CR10X data acquisition systems, as shown in the block diagram of Figure 6. There will be one CR10X per fuel cell system. ASU-PTL personnel chose the CR10X because of its durability and reliability, as well as a familiarity of the system.

One CR10X will be connected to the Internet via a Campbell Scientific NL100 Ethernet adapter. The other will be connected through an RF400 - a 900MHz radio transmitter/receiver specifically designed for CR10X use in remote areas. The CR10X can connect to the NL100 through the RF400, allowing its data to be downloadable over the Internet. PC208W software, also from Campbell Scientific, will be used to

retrieve the data at a local PC, where it will be stored in .CSV files and translated to an Excel spreadsheet.

The Plug Power Gensys system has an onboard computer that can collect data every minute when hooked up through a direct line to a PC, through an RS232 cable. However, in this application, the unit will be remote, and requires downloading through the phone line. According to Plug Power, 30 columns of data (collected in 10-minute intervals) can be downloaded on a nightly basis. If it is possible, ASU-PTL will program the Plug Power unit to call the data in to a local PC every night. This data will then be copied and sent to Plug Power on a weekly basis. If this cannot be achieved, Plug Power will collect the data in Latham, NY and send a copy of the data to ASU-PTL on a weekly basis.

The IdaTech unit will be hooked directly to the Internet through modem provided by the local telephone company. Only ISDN services are available at the location of the two fuel cell systems.

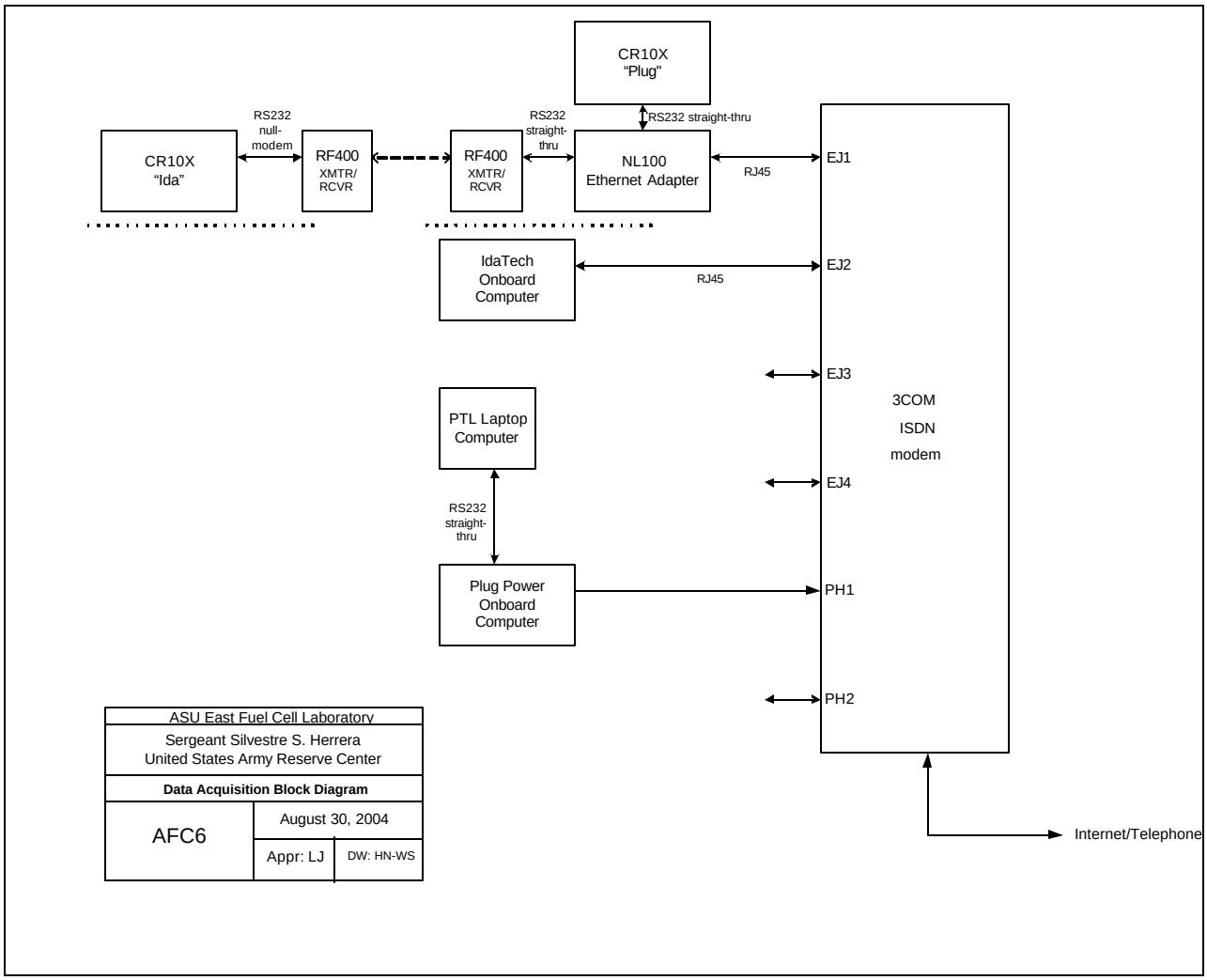


Figure 7. Block diagram of data acquisition system

12.0 Economic Analysis

This analysis is carried out based on the real costs of electricity (output) and natural gas (input).

Expected NET ENERGY SAVINGS for the Plug Power Gensys® 5C fuel cell system

SRP electric utility rate for business: $0.0804/kWh
1 Therm = 29.31 kWh
Southwest Gas tariff for Armed Forces (fuel rate): $0.75058/Therm

Output at 90% availability: 2.5 kW * 8760 hours/year * 0.90 = 19,710 kWh

OUTPUT SAVINGS PER YEAR: 19,710 kWh * $0.0804/kWh = $1,585

Plug Power reported efficiency at 2.5 kW: 26%
Input at 90% availability (kWh): 19,710 kWh/0.26 = 75,808 kWh
Input at 90% availability (Therms): 75,808 kWh * 1 Therm/29.31 kWh = 2,586 Therms

INPUT COST PER YEAR: 2,586 Therms * $0.75058/Therm = $1,941

NET ANNUAL ENERGY COST DIFFERENCE:
$1,585 - $1,941 = - $356

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Expected NET ENERGY SAVINGS for the IdaTech fuel cell system

SRP electric utility rate for business: $0.0804/kWh
1 Therm = 29.31 kWh
Southwest Gas tariff for Armed Forces (fuel rate): $0.75058/Therm

Output at 90% availability: 2 kW * 8760 hours/year * 0.90 = 15,768 kWh

OUTPUT SAVINGS PER YEAR: 15,768 kWh * $0.0804/kWh = $1,268

IdaTech reported efficiency at 2 kW: 25%
Input at 90% availability (kWh): 15,768 kWh/0.25 = 63,072 kWh
Input at 90% availability (Therms): 63,072 kWh * 1 Therm/29.31 kWh = 2,152 Therms

INPUT COST PER YEAR: 2,152 Therms * $0.75058/Therm = $1,615

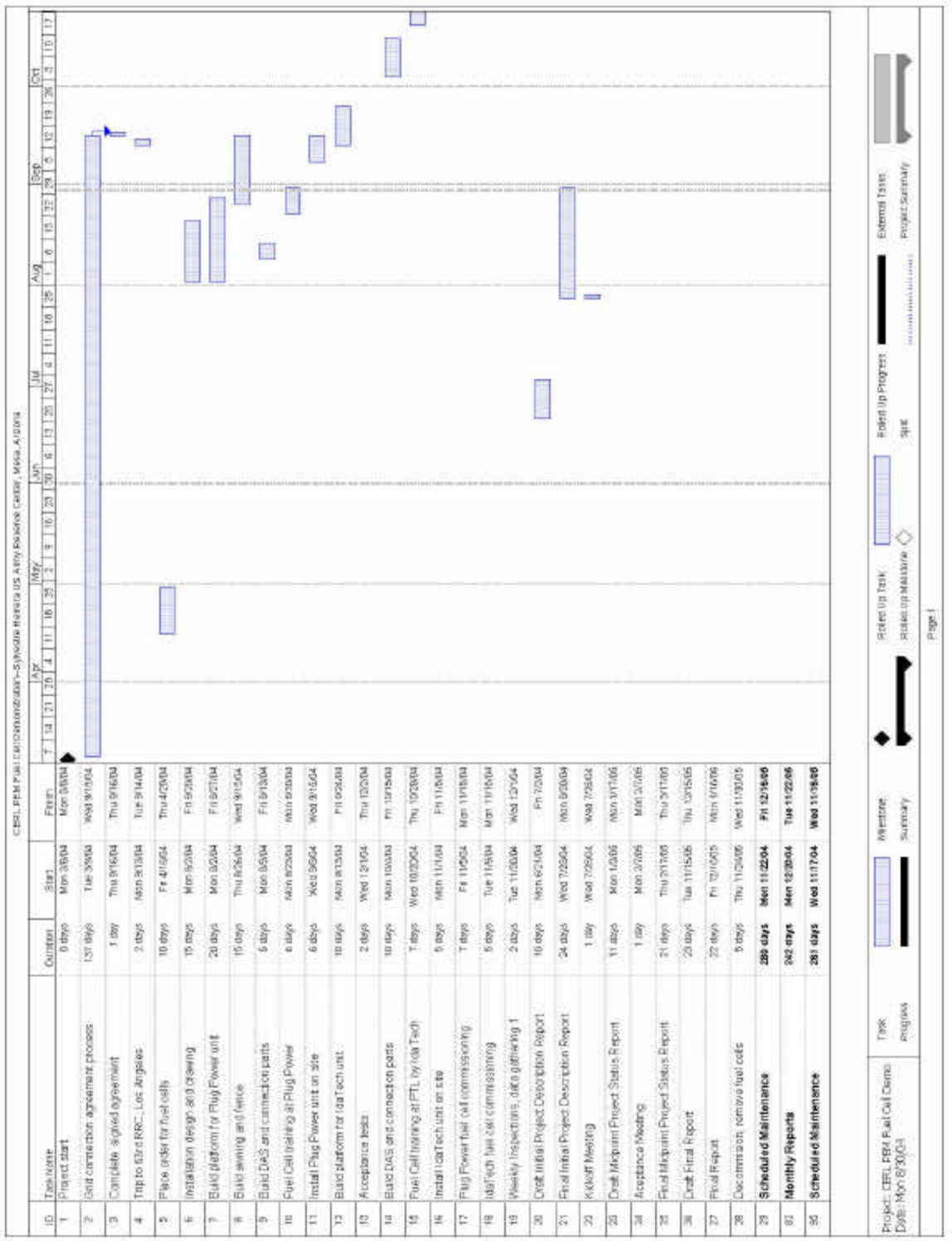
NET ANNUAL ENERGY COST DIFFERENCE:
$1,268 - $1,615 = - $347

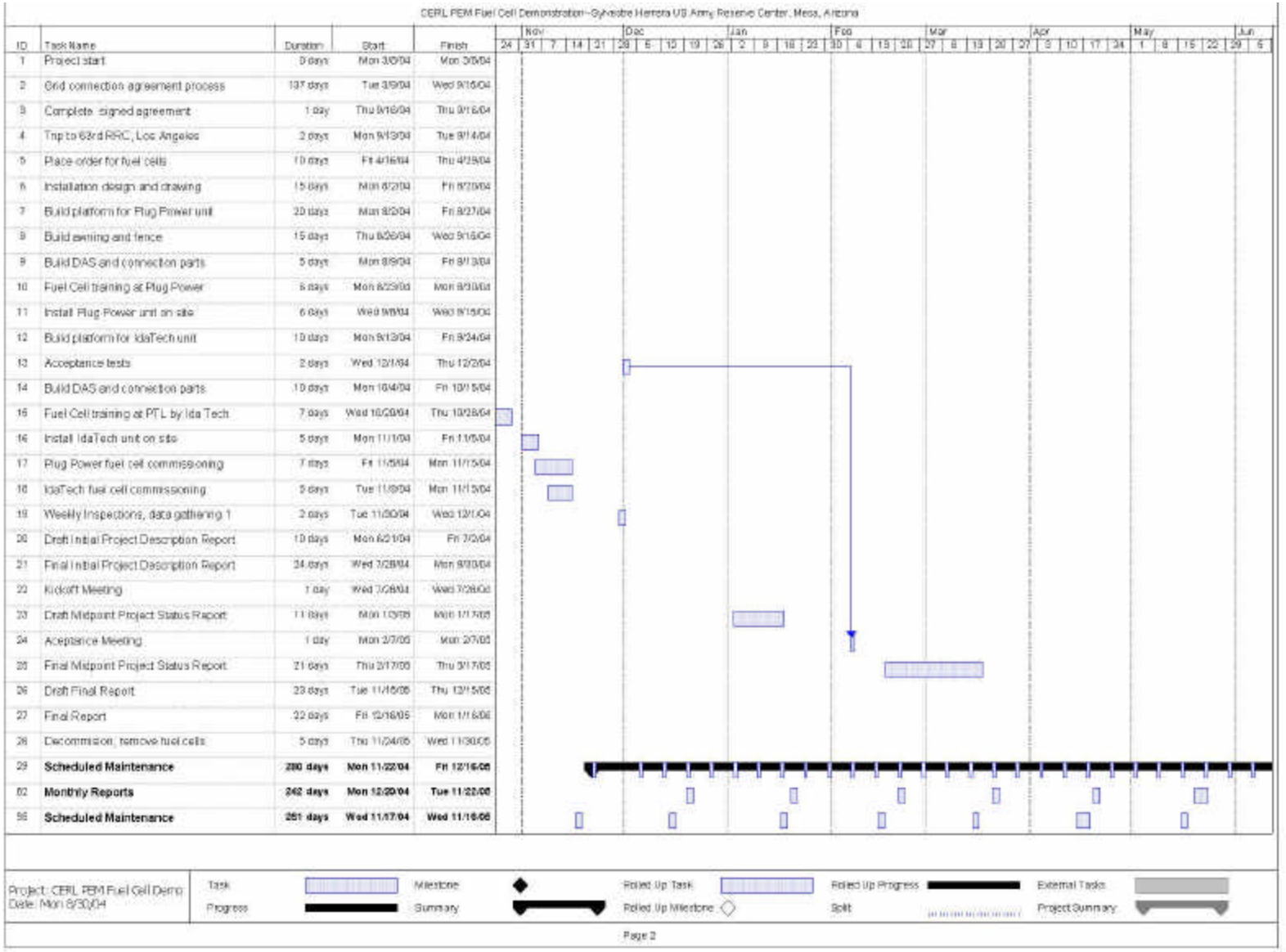
13.0 Kickoff Meeting Information

The kickoff meeting was held on Wednesday, July 28, 2004. Dr. Michael Binder represented CERL. Mr. James Cresto represented the 63rd RCC. Introductions of all attendees was made, then an overview of the project presented. Mr. Cresto indicated formal agreement in the form of an e-mail by the 63rd RRC Chief, Facility Engineering, Dr. Michael Siu, in the proposed Building 620 location, would follow. Status of fuel cell orders, was discussed. Plug Power unit has been received, while Ida Tech will not ship its unit until the first week of November. Ida Tech will not be able to have its inverter listed to UL 1741, however, the design of the inverter is UL 1741 compliant. Salt River Project, the local utility, has been made aware of this fact, but with the tripping relays that must be installed in addition to the built-in protection in each fuel cell, it does accept the fact the unit will not be listed. The utility is only interested in protecting its lines in the case of faults and believes its added relay requirements will suffice. An inspection of the proposed site was made. No objections to its selection were voiced.

14.0 Status/Timeline

Clock starting time for operating the two fuel cells is expected to be 15 November 2004 (from ID numbers 17 and 18 in the attached prjoect schedule). Clock stopping time is expected to be one year later at 15 November 2005 (ID #26, that begins the draft final report). Decommissioning is scheduled for 30 November 2005 (ID #28).




CERL PEM Fuel Cell Demonstration--Sylvestre Herrera US Army Reserve Center, Mesa, Arizona
Nov
Dec
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Feb
Mar
Apr
May
Jun
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1 Project start 0 days Mon 3/8/04 Mon 3/8/04
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3 Complete signed agreement 1 day Thu 9/16/04 Thu 9/16/04
4 Trip to 63rd RRC, Los Angeles 2 days Mon 9/13/04 Tue 9/14/04
5 Place order for fuel cells 10 days Fri 4/16/04 Thu 4/29/04
6 Installation design and drawing 15 days Mon 8/2/04 Fri 8/20/04
7 Build platform for Plug Power unit 20 days Mon 8/2/04 Fri 8/27/04
8 Build awning and fence 15 days Thu 8/26/04 Wed 9/15/04
9 Build DAS and connection parts 5 days Mon 8/9/04 Fri 8/13/04
10 Fuel Cell training at Plug Power 5 days Mon 8/23/04 Mon 8/30/04
11 Install Plug Power unit on site 6 days Wed 9/8/04 Wed 9/15/04
12 Build platform for IdaTech unit 10 days Mon 9/13/04 Fri 9/24/04
13 Acceptance tests 2 days Wed 12/1/04 Thu 12/2/04
14 Build DAS and connection parts 10 days Mon 10/4/04 Fri 10/15/04
15 Fuel Cell training at PTL by Ida Tech 7 days Wed 10/20/04 Thu 10/28/04
16 Install IdaTech unit on site 5 days Mon 11/1/04 Fri 11/5/04
17 Plug Power fuel cell commissioning 7 days Fri 11/5/04 Mon 11/15/04
18 IdaTech fuel cell commissioning 5 days Tue 11/9/04 Mon 11/15/04
19 Weekly Inspections, data gathering 1 2 days Tue 11/30/04 Wed 12/1/04
20 Draft Initial Project Description Report 10 days Mon 6/21/04 Fri 7/2/04
21 Final Initial Project Description Report 24 days Wed 7/28/04 Mon 8/30/04
22 Kickoff Meeting 1 day Wed 7/28/04 Wed 7/28/04
23 Draft Midpoint Project Status Report 11 days Mon 1/3/05 Mon 1/17/05
24 Acceptance Meeting 1 day Mon 2/7/05 Mon 2/7/05
25 Final Midpoint Project Status Report 21 days Thu 2/17/05 Thu 3/17/05
26 Draft Final Report 23 days Tue 11/15/05 Thu 12/15/05
27 Final Report 22 days Fri 12/16/05 Mon 1/16/06
28 Decommision, remove fuel cells 5 days Thu 11/24/05 Wed 11/30/05
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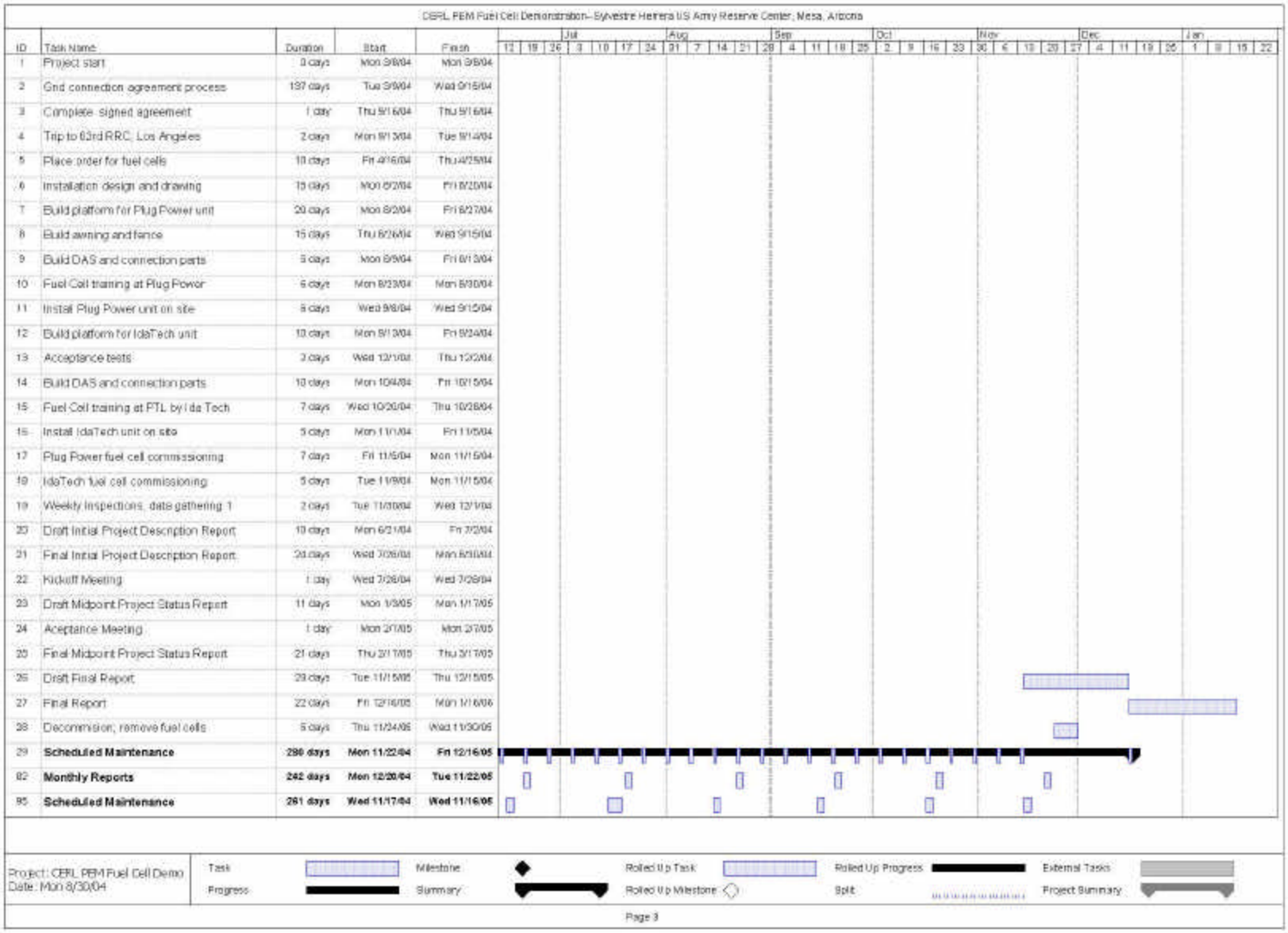
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27 Final Report 22 days Fri 12/16/05 Mon 1/16/06
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29 Scheduled Maintenance 290 days Mon 11/22/04 Fri 12/16/05
82 Monthly Reports 242 days Mon 12/20/04 Tue 11/22/05
85 Scheduled Maintenance 261 days Wed 11/17/04 Wed 11/16/05
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Date: Mon 8/30/04
Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress
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